B.14 ASTROBIOLOGY SCIENCE AND TECHNOLOGY FOR EXPLORING PLANETS

IMPORTANT NOTICE

Although the due dates for this program given in Tables 3 and 4 of the *Summary of Solicitation* of this NRA are considered valid, certain critical details in Section 2, *Programmatic Information*, below are still under development at the time of this NRA's initial release. Therefore, the following material is provided only as a placeholder for the final program description that will be released as an addendum to this NRA at least 90 days before the proposal due date.

1. Scope of Program

1.1 Introduction

A new era of planetary surface exploration has begun that is now investigating whether life exists or has existed beyond Earth that requires the development of biologically relevant, miniaturized instrumentation capable of extensive, autonomous operations on planetary surfaces (Mars first, then throughout the Solar System). To this end, and in collaboration with the other agencies, this Astrobiology Science and Technology for Exploring Planets (ASTEP) program solicits proposals for investigations to explore the Earth's extreme environments in order to develop a sound technical and scientific basis to search for life on other planets. The ASTEP program is a science-driven exploration program that is expected to result in new science and operational/technological capabilities that enable the next generation of planetary exploration. A unique feature that is central to the ASTEP program is the use of terrestrial field campaigns to further science and technology. Therefore, proposals that combine the following three concerted objectives will be given priority:

1) Science: ASTEP seeks science investigations designed to further biological research in the terrestrial environments analogous to those found on other planets, past or present. Such investigations should increase our understanding of the limits and constraints (or lack thereof) of life in extreme environments and, therefore, lead to a better understanding of how to seek, identify, and characterize life that may exist or have existed on other planets.
2) Technology: ASTEP seeks the development of technologies that enable remote searches for, and identification of, life in extreme environments (including planetary surfaces) including, but not limited to, *in situ* laboratories, sample acquisition and handling techniques, remote sample manipulation, mobile science systems (including planetary rovers), techniques for autonomous operations, and self-contained deployment systems.
3) Field Campaigns: ASTEP supports systems-level field campaigns designed to demonstrate and validate the science and technology in extreme environments on Earth. It is expected that such field campaigns will be conducted with complete systems and in a manner that approximates their operations in an actual planetary

mission in order to understand the performance, capabilities, and efficiencies associated with the tested systems, as well as gain operational experience.

In summary, ASTEP is expected to lower the risks of planetary exploration through technology development and systems-level field tests in Earth's extreme environments that will also obtain scientific data and operational experience.

The high visibility missions to the Earth's extreme environments that are expected to be supported through this program element should also provide significant opportunities for student involvement in exploration, thereby inspiring a technologically competent next generation of scientists, engineers, and citizens. Therefore, proposals to ASTEP that provide for student involvement (both graduate as well as undergraduate) are encouraged. In addition, proposals are also sought that incorporate Education/Public Outreach (E/PO) activities through telepresence capabilities and involvement of professional educators and students nation-wide in the fun and challenges of science and technology. Further guidance on the E/PO program sponsored by the Office of Space Science may be found in Section I(b) of the *Summary of Solicitation* of this NRA. Conversely, proposers who prefer not to propose a significant E/PO effort should state in their proposals whether they are willing to host an outside E/PO activity arranged by NASA.

In recognizing the needed development of miniaturized instrument systems, with this solicitation NASA is also soliciting "lab-in-a-teacup" development projects. The goal is to apply micro/nanotechnology to planetary instrumentation and highly integrated miniature instruments suites with the capability to address astrobiology interests in planetary exploration. This is a specific call for instrumentation, without necessarily being associated with a field campaign.

Note that to enable the NASA Office of Space Science to properly evaluate the relevance of proposals submitted to its programs, as well as track its progress towards achieving its goals as mandated by the Government Performance Review Act (GPRA) of 1993, all research supported by NASA's programs must now demonstrate its relationship to NASA Goals and Research Focus Areas (RFAs) as stated in the latest version of its Strategic Plan (follow links from the Web site http://spacescience.nasa.gov/); see also the discussion in Section I of the *Summary of Solicitation* of this NRA. Therefore, all proposers to this program element are asked to state their perception of this relevance in terms of the Goals, Science Objectives, and RFAs given in Table 1 found in the *Summary of Solicitation*. In particular, this program element is designed to help fulfill all of the RFAs for the Science Objectives 2 and 3 of the Solar System Exploration science theme. The appropriate place for this statement of relevancy is in the introduction to the proposal's "Scientific/Technical/Management" section (see Section 2.3.5 in the *Guidebook for Proposers*). The index numbers in this table may be used to identify a specific RFA, for example, "Goal I, Sun-Earth Connection Theme, RFA 1(c)" or "Goal II, Astronomical Search for Origins, RFA 3(b)."

1.2 Program Guidelines and Constraints

Astrobiology is the study of life in the Universe whose goals and objectives are detailed in the Astrobiology Roadmap (see http://astrobiology.arc.nasa.gov/). The Office of Space Science has planned and is planning missions to Mars and to other planetary bodies of Astrobiology interest (see http://spacescience.nasa.gov/).

It is intended that the products of the ASTEP Program will be initially utilized by the space flight projects planned for the NASA Mars Exploration Program (MEP) (http://mars.jpl.nasa.gov/) and the NASA Solar System Exploration Program (http://sse.jpl.nasa.gov/).

Technology development and field test campaign proposals in all areas relevant to astrobiology and planetary exploration goals and objectives will be considered for the ASTEP program. However, the program recognizes a particular need for proposals for technology maturation, science data collection, and operations analysis in the following areas:

- Surface sample acquisition, handling, and distribution systems;
- Instrument suites for *in situ* identification and analysis of biomarkers;
- Long-term characterization of life-supporting environments;
- Integration of science instrument suites with mobile platforms (rovers);
- Autonomous instrument deployment and placement;
- Autonomous recognition of unexpected science phenomena;
- Self-contained mobile science systems;
- Mobile science platforms; and
- Subsurface sample acquisition systems.

Several science and technology development programs have produced component technologies, capabilities, and resources that may be of utility in constructing complete systems for field test campaigns or further technology development. Utilization and leveraging of these component technologies and/or subsystems is permitted and encouraged. References and further information on these representative technologies can be found at http://ranier.hq.nasa.gov/ASTEP/astep.html.

1.3 Campaigns for Field Tests

Field campaigns for the testing of technologies relevant to this ASTEP program may be proposed and may cover a wide range of environments that are analogous to different past or present planetary environments. Examples of field test campaigns are given below to demonstrate the breadth, applicability, and excitement of this approach (Note: these examples are only representative of possible campaigns and do not represent either explicitly or exclusively all possibilities). Finally, note that while proposals for field test campaigns are encouraged in response to this solicitation, it is incumbent on the proposer to demonstrate that access to the site proposed for the operation of experiment apparatus is in fact tenable both physically and, for those locales not under the control of the U.S., politically, and that appropriate budget resources are allocated for the operations.

Remote Explorer

Ground-based systems can provide platforms for detailed local investigations of regions identified as likely candidate locations for the detection of life signs. For example, such a project might seek to validate remote long duration and autonomous science operations and technologies by combining an existing mobile robotic platform with a representative suite of astrobiology instruments, deploying the system in a remote location (for example, the Earth's polar regions), and operating the system from the continental U.S. through a telecommunications link consistent with those used for communications with NASA's planetary missions.

Volcanic Firewalker

Ancient and active volcanoes exist throughout the solar system and may have provided key ingredients for life-supporting environments (energy, chemistry, and possibly liquid water) and, therefore, are high priority targets for searches for evidence of life. Thus, the deployment of a robotic exploration system to search and analyze the interior of volcanic craters, including fumaroles, to identify potential habitats for life could validate science operations and technologies for exploring similar features on other planets.

Ice Penetrator

Sub-ice oceans on Europa may harbor life-supporting environments. Methods and technologies for accessing and exploring environments beneath deep ice cover are not well understood and could be tested in the Earth's own polar regions. Such efforts would focus on the technical challenges of ice penetration, of planetary protection through the use of non-contaminating sampling techniques, of the potential for environmental degradation, of communication and exploration systems, and of biomarker identification in extremely low-energy environments.

Hydrothermal Vent Monitor

Using the terrestrial subsurface ocean environment as an analog for Europa or other early planetary environments, a campaign to conduct long term examinations of deep sea volcanic vents, as well as more violent eruptions that could even bring life forms from far beneath the sea floor to the surface, would be relevant to the ASTEP program. Deep-sea exploration platforms ("aqua-bots") exist but require considerable surface infrastructure that is not tenable for a space flight mission. However, it might be possible to modify such a system for stand-alone operation in support of biology science packages. Such a campaign might conduct operations with only minimal intervention for many months or even years, therefore, requiring the development of systems having a significant degree of autonomy.

2. Programmatic Information

To be provided at the time of the final release of this program description; see notice at the beginning of this program description.

Questions concerning this ASTEP program may be directed to either of the following Program Officers:

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